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TSUNAMIS IN THE BLACK SEA - Z.K. Grigorash and L.A. Korneva

Tsunamis in the USSR usually occur on the Pacific shores of Kamchatka and Kuril Islands, but some have been observed in the Black and the Caspian Seas where earthquakes are rather common. The principal seismic zone in the Black Sea stretches along the coasts of Crimea and Caucasus.

The history of earthquakes in Crimea begins in the Thirteenth Century A.D., but mention of an earthquake in 480 A.D. has beer made.

The seismicity of Crimea was studied in detail after the earthquakes of June 26 and September 12, 1927, the two strongest earthquakes in the history of the area. Both of these earthquakes generated small tsunamis (Grigorash, 1959 a,b). The maximum wave heights were approximately 0.5 meter, and waves were recorded by almost all of the tide gage stations in the Black Sea (Dvoichenko, 1928).

The instrumental study of the seismicity of Caucasus began in 1911. Prior to 1911, two historical tsunamis are reported (I.V. Ananyin, personal communication). The first occurred in Sukhumi in the First Century B.C. and the second in Anapa on October 4, 1905. The area from Anapa to Sochi is the most active seismic zone in the West Caucasus (Ananyin, 1966), and about half of all the earthquakes that have occurred in the area had their epicenters in the sea. One of the largest earthquakes occurred in the area on October 21, 1905. Its epicenter was in the Black Sea and because of its large magnitude, it must have generated a tsunami. Another tsunamigenic earthquake in Caucasus occurred at 18:53 GMT, July 12, 1966 ($M=5\frac{1}{4}-5\frac{1}{2}$) in the vicinity of Anapa at 44.7° N, 37.2° E. Tide gage records of this tsunami have been obtained, and tsunami travel times for different places have been determined and compared with computed travel times. A wave refraction diagram of this tsunami is given below.

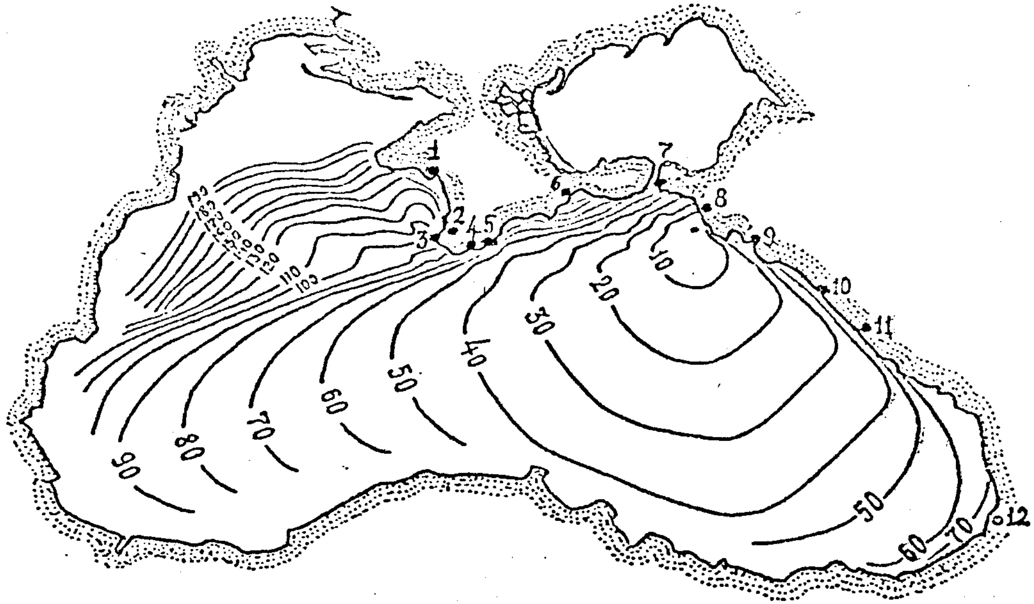

Fig. 1. The wave fronts at 10-minute intervals for the Anapian tsunami of July 12, 1966. (1-Evpatoriya; 2-Sebastopol; 3-C.Khersones; 4-Katsiveli; 5-Yalta; 6-Feodosiya; 7-Kechen St.; 8-Anapa; 9-Gelengic; 10-Tuapse; 11-Sochi; 12-Batumi).

REFERENCES:

Ananyin, I.V. "Seismicity of the West Caucasus, the East Part of the Black Sea and Relationship Between It and the Interior Structure of the Earth's Crust," Akademia Nauk USSR. Mezhduvedomstvennyi Geofizicheskii Komitet, Sbornik Statei "The Structure of the Black Sea Trough," Moscow, Izdatel'stvo "Nauka", 1966.

Dvoichenko, P.A. "The Black Sea Earthquakes of 1927 in the Crimea," Priroda, N 6, 1928, 523-542.

Grigorash, Z.K. "The Black Sea Tsunamis of 1927 on the Mareographic Records," Akademiia Nauk USSR, Morskoi Gidrofizicheskii Institut, Trudy, Moscow, vol. XVII, 1959a, 56-67.

Grigorash, Z.K. "The Propagation of the Tsunamis of 1927 in the Black Sea," Akademiia Nauk USSR, Morskoi Gidrofizicheskii Institut, Trudy, Moscow, vol. XVIII, 1959b, 113-116.

TSUNAMI WARNING GAUGES - TOFINO AND VICTORIA - G.C. Dohler

Mr. G.C. Dohler, head of the Tides & Water Levels Division of the Canadian Department of Energy, Mines and Resources, has sent ITIC the following description of the new automatic tsunami warning gauges recently installed at Tofino and Victoria. For a better appreciation of these tsunami warning gauges it is imperative to understand the automated sequential operations performed by these instruments, including the three basic modes consisting of: a) the Normal Tidal Mode; b) the Warning Mode; and c) the Sampling Mode.

The Normal Tidal Mode of Operation: The incident water level is available at any time from a mechanical electrical digitizer connected to a float with chain and counter weight. Water level changes are transmitted to the digitizer corresponding to the existing value which in turn is referred to a pre-determined datum plane.

The instantaneous water level announcement preceded by the words, "automatic announcing service - water level in centimeter" gives in every mode of operation precisely the level at the time of interrogation. The other two announcements during this normal operation are the tendency and the words "last high water" or "last low water," followed by the respective values thereof. The words "No tsunami registered and End of Announcement" conclude the cycle of this mode.

A tendency change will not activate the memory unit of the apparatus at the time the highest or lowest water elevation has been reached, nor will it be at the highest or lowest elevation stored in the memory because first, the following conditions have to be met: a) The amplitude causing a reversal must be more than 20 centimeters for the Tofino gauges and 14 centimeters for the Victoria gauge; b) If these vertical changes have been reached, the tendency in the same direction must be for at least 5 minutes.

As soon as these two conditions are fulfilled, the new tendency and the water level value are entered in the memory unit of the instrument. The tsunami warning gauges at Victoria and Tofino are adjusted to the settings just mentioned.

Because of the importance of this sequential delay arrangement let us assume the tide is rising and upon interrogation, the announcement will be:

Automatic Announcing Service....Water Levels in Centimeters....306, 306
Tendency Rising................Last Low Water................213, 213
No Tsunami Registered..........End of Announcement

The water level is still rising and the point of high water will be reached at 327 centimeters. The water must now fall 20 centimeters (14 for Victoria) before the tendency relay will start running for 5 minutes. After these 5 minutes the new tendency will go into the tidal register and from now on the announcement will be ... Tendency Falling, Last High Water, 315 ... Observe that it will not announce 307 (313 for Victoria) since this was the level at which the tendency delay started running, and during the 5-minute time elapse, the water level has fallen further before the new high water was registered.

These delays are necessary to reduce the possibility of false messages. It must be kept in mind, however, that any disturbances in excess of the aforementioned conditions and different from the normal tidal oscillation will be regarded by the instrument as a tsunami. Human interpretation of these oscillations is required in arriving at a conclusion and making decisions.

The Warning Mode: For the Victoria and Tofino stations the time difference between sucessive high and low waters has been established at 4.5 hours. If a change of tendency occurs within this span of time, then an alarm signal will be triggered. For this reason, an adjustable timer has been employed which, after running for 4.5 hours, will connect itself from the circuitry. In other words, while this timer is switched on, the operation sequence of the instrument is changed from normal to warning and the signal issued from a change of tendency will not during that time, initiate the storage of the instantaneous water level in the tidal register. Instead, this level will be stored in the first of the 10 tsunami registers. After this, the apparatus will dial a telephone number to deliver its warning message, ...Warning Tsunami, Warning Tsunami... This message will be sent for about 2 minutes to a pre-assigned number. At the same time and by means of a set of slave contacts, other processes could be initiated. For example, at Victoria a punch paper recorder is switched on to operate for 24 hours, punching at 1-minute intervals the course of the water level.

The Sampling Mode: After the warning message has been delivered the unit will change to the sampling sequence of operation. It will collect the water level nine more times at intervals of 5 minutes. This means that once a warning message has been initiated, some 7 to 8 minutes thereafter all other values will enter the tsunami register at intervals of 5 minutes if the apparatus remains undisturbed from outside calls. If addressed before all samples have been accumulated, then the unit will recount to the caller the numerical value of the samples taken up to that particular time. For the remaining registers, however, only zeros will will be announced. For example:

Automatic Announcing Service....Water Level in Centimeters....250, 250
Tendency Rising................Tsunami Registered as follows:
Sample a 259 Sample b 232 Sample c 317 Sample d 294
Sample e 322 Sample f to Sample k 000

Depending on how often the station was addressed during the sampling time, a complete announcement will be available some 50 minutes after the warning message was delivered. After this, all values will remain in the register until the timer, which in our case was set to 4.5 hours, has run out. It should be noted that during this time the station will announce the same information again, if and when interrogated.

Should, after the elapsed time of 4.5 hours and before a real tide change was reached, an oscillation occur which does meet the conditions mentioned earlier, then the instrument will start in the same manner as described previously its three modes of operation.

If for some reason the electrical supply to the station was interrupted during a tsunami sampling period, the instrument will be reset and will announce a normal tidal condition. Only further oscillations, or a real tidal change after the power break, will reset the station to announce in its proper sequence. The punch paper tape recorder will also stop collecting until the power is being restored.

TSUNAMI TRAVEL TIME CHARTS - G. Miller and G. Pararas-Carayannis

Volume I, Number 1 of the ITIC Newsletter contained a brief description of a generalized computer method for the production of travel-time charts. This program has been used to produce a series of charts similar to that shown in Fig. 1. Table 1 lists the locations for which completed charts exist; these charts will soon be available for distribution.

The actual computations are made for the wave rays rather than the wave fronts. Points of equal travel time along these rays are then connected together to form the "wave fronts" shown in the figure. Input data to the computer consist of depths on a one degree grid and the origin and direction of the wave ray. The depths h are converted to velocities c using the relationship $c=\sqrt{gh}$ where g is the acceleration due to gravity. This approximate formula is valid for waves having a period greater than 4 minutes. If a tsunami were generated with a shorter period than this, a more exact formula for the wave speed would be used.

A general formula for the curvature K of a wave ray is $K = \frac{1}{c}\left[\sin\alpha \frac{\partial c}{\partial x} - \cos\alpha \frac{\partial c}{\partial y}\right]$ where α is the angle between the ray and the x-axis. In the program, the partial derivatives are taken as the differences between weighted averages calculated over small regions near the end of the ray. Since the basic depth data are given in spherical coordinates, the rays are computed in the spherical coordinate system also. The formula given for the curvature is transformed by rotation at each step in the computation so that α is 45° relative to the direction of wave propagation. This assures that the averages used to determine the partial derivatives are symmetrical about the ray path.

The step size used in the computation of the wave rays may be determined by the user. If the step size chosen is too large, the ray will not be retraceable because the velocity field will vary significantly over the step size. In that case the program cuts the step size in half and proceeds, returning to the original step size in areas where the velocity field varies relatively slowly. For the travel-time charts listed in Table 1, the step size was approximately 220 km and the effective radius of the weighting function used to determine the partial derivatives was approximately 200 km.

It is planned to complete travel-time charts for the following stations: Neah Bay, Wake I., Balboa, Johnston I., Kodiak, Acajutla, Antofagasta, Arica, Easter I., Puerto Monti, Puerto Williams, Punta Arenas, Talcahuano, Truk I., New Caledonia, and any other stations that may be added to the Tsunami Warning System.

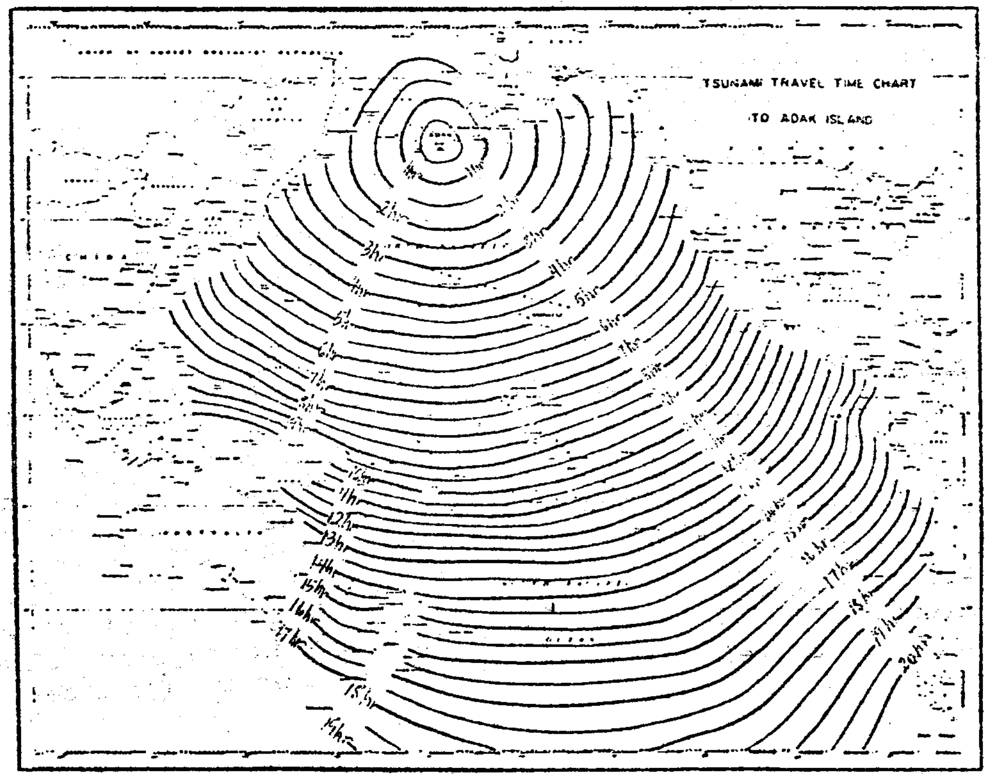

Figure 1. Tsunami Travel Time Chart

Table 1. List of Completed Charts

Acapulco	Eniwetok I.	Nauru I.
Adak I.	Kwajalein Atoll	San Francisco
Attu I.	La Punta	Seward
Canton I.	La Jolla	Sitka
Crescent City	Los Angeles	Tofino
Dutch Harbor	Marcus I.	

EXPERIMENTAL LOCAL TWS FOR HAWAIIAN ISLANDS

In an effort to provide earlier information on locally generated tsunamis, a new Tsunami Warning System will be established on an experimental basis in the Hawaiian Islands. The new system, which will be established by U.S. ESSA's Coast & Geodetic Survey and the University of Hawaii, will supplement the Warning System now in existence in Hawaii. The work will be performed by the University's Institute of Geophysics under the supervision of Drs. William M. Adams and Martin Vitousek. The ESSA liaison officer for the project is ITIC Director Robert Munson.

The experimental system will consist of seismic and hydraulic gage stations on various islands of the Hawaiian group. Signals from these will be telemetered by radio to ITIC's Honolulu Observatory.

The new system will supplement an existing seismic quadripartite warning net on the island of Oahu, which is part of the Pacific tsunami warning system. Three seismic stations will be established on the island of Hawaii in cooperation with the U.S. Geological Survey's Hawaii Volcano Observatory, and another one will be installed on Maui. The system will also use an existing hydraulic gage on West Coast of the island of Hawaii, plus a new one to be installed on the south coast of the island.

In addition, an ocean bottom tsunami recorder using a mid-ocean pressure sensor will be assembled and placed under the ocean station ship located north of the Hawaiian Islands. The pressure sensor will telemeter wave height data from the sea bottom to the ship where the signals will be relayed to the Honolulu Observatory.

It is expected that data from this system will appreciably reduce the time in which a warning can be issued for a tsunami generated near the Hawaiian Islands.

OCEANOGRAPHIC DATA SERVICE FREQUENCIES FOR THE TSUNAMI WARNING SYSTEM

An evaluation of the telecommunication needs for the Tsunami Warning System was made by the Intergovernmental Coordinating Group on the TWS at the March, 1968, meeting in Honolulu. It was then pointed out that 12 communication channels would be needed in the six frequency bands assigned by WARC. These channels were requested so that the ITIC would be in a position to collect and interpret on a real-time basis, seismic and sea-level data from ocean and coastal stations. A reassessment of ITIC requirements shows that the six frequency bands allocated IGOSS by WARC are not reliable for long-range transmission (in excess of 1,000 miles).

In light of the projected expansion of the TWS the new requirements call for: 1) At least one voice channel for passing watch and warning information between the Honolulu Observatory and the islands and countries throughout and surrounding the Pacific Ocean; 2) At least 30 channels for the transmission of data to the Honolulu Observatory from various participating stations throughout the Pacific area.

It is anticipated that, although the TWS will have approximately 120 tide stations and 30 seismograph stations, no more than 30 stations will transmit at any time. A request has been sent to the IOC to take steps in the coordination of these additional needs of the TWS.

SPANISH TRANSLATION OF WAVE REPORTING PROCEDURES FOR TWS

The Hydrography Division of Peru, under the direction of Radm. Jorge Camino de la Torre, has translated and published in Spanish publication 30-3 (1966) of the U.S. Coast & Geodetic Survey entitled "Wave Reporting Procedures for Tide Observers in the Seismic Sea Wave Warning System." The translated publication has been distributed to all the tide gage stations in Peru and to all Departments of Hydrography in the Spanish-speaking Latin American countries.

THE TSUNAMI OF APRIL 1, 1968 - JAPAN

An investigation of the tsunami which accompanied the Hiuganada earthquake of April 1, 1968, has been completed by Drs. Kajiura, Aida, and Hatori of the Earthquake Research Institute. The results of this investigation were published in the Bulletin of the Institute, vol. 46 (1968), pp. 1149-1168.

According to their findings, tsunami waves of moderate size arrived 20 minutes after the occurrence of the earthquake at southwestern Shikoku and eastern Kyushu. Maximum run-up height was more than 3 meters at Urashiri, Shikoku. Elsewhere along the coast facing the tsunami generating area, maximum double amplitudes of the tsunami waves were 2 to 2.5 meters on the average. The generating area was found to be an elongated ellipse whose major axis was in an almost east-west direction, about 60 km long, and approximately parallel to water depth contours.

MINOR TSUNAMI - AUGUST 1, 1968 - PHILIPPINES

Definable tsunami activity from the Philippine earthquake of 2019Z, August 1, 1968, was observed in the tide station marigrams of Wake Island, Guam, Honolulu, and Nawiliwili. Detectable activity is present on several other marigrams, but mixed with natural seiche activity. No wave heights in excess of 0.08 m were observed.

THE TSUNAMI OF AUGUST 14, 1968 - INDONESIA

Appearing in the September 5, 1968, issue of the ITIC Newsletter (p. 5) was an item concerning the tsunamis associated with the earthquakes of August 10 and 14, 1968. Additional information regarding fatalities, injuries, and damages resulting from the tsunami of August 14, 1968, has reached ITIC from the Indonesian Hydrographic Office.

Tsunami waves 9-10 meters in height battered the east coast of the Donggala district, Celebes Island, and penetrated inland as much as 500 meters. One hundred-sixty persons were killed, 40 were lost, and 58 were injured. A total of 800 houses along the coast were destroyed and large areas of coconut plantations were inundated.

MAKASSAR STRAIT EARTHQUAKE AND TSUNAMI - FEBRUARY 23, 1969

A large earthquake of magnitude 6.9 on the Richter scale occurred at 00:37 GMT, February 23, 1969. The epicenter of this earthquake was at 3.1° S, 118.9° E. A large tsunami was generated along the west coast of Celebes Island and struck the town of Madjene and the city of Makassar. More than 2,000 persons fled from coastal areas to escape the tsunami waves. Four villages were swept away. According to reports received, 20 persons were killed and some buildings toppled in the city of Makassar. At least 600 persons are missing and believed dead along the west coast of Celebes Island. It is not known at this time whether the fatalities and the damages were the result of the earthquake or the tsunami. The epicenter of this recent earthquake is in the approximate area as that of the August 10 and 14, 1968, earthquakes.

EARTHQUAKE AND TSUNAMI OF FEBRUARY 28, 1969 - PORTUGAL

The strongest earthquake in 5 years (M=8.0) occurred in the Eastern Atlantic at 02:40:28 GMT, February 28, 1969. Its epicenter was located at 36.0° N, 10.6° W, near Portugal. The main event and subsequent aftershocks were strongly felt in Spain, Portugal, and Morocco, resulting in fatalities, injuries, and destruction of property. A tsunami having an amplitude of 1.2 meters in height was reported at Casablanca. The tsunami waves had an initial period of 10 minutes increasing later to 23 minutes. The tsunami was also reported from the Gulf of Cadiz and the Canary Islands where the amplitude was less than 1 meter. Tide records have been requested. The tsunami arrived at Casablanca at 03:26 GMT. Initial motion was a fall. The average speed, assuming the tsunami generating area to coincide with the epicenter, was 470 km per hour.

NORTH PACIFIC BUOY SYSTEM TO BE TESTED

During the month of May a new buoy system for transmission of tsunami data will be placed approximately 1,000 km north of the Hawaiian Islands. The system consists of a bottom-mounted pressure sensor with an associated acoustic transponder, and a spar-buoy subsystem with acoustic transponder for communication with the bottom-mounted unit. Communication with the buoy from shore is by means of meteor-bounce telemetry. As with any buoy system there is always the danger that the mooring may part; thus the addresses of each of the tsunami warning centers of the nations in the Tsunami Warning System will be on the buoy. In this way, if the buoy is found adrift, the finder will have an appropriate and convenient place to forward the information. The University of Hawaii and ESSA are cooperating in the construction and placement of this buoy system; Dr. Martin Vitousek is senior scientist on the project.

TSUNAMI INVESTIGATIONS - JANUARY-APRIL 1969

GMT Date & Time 1969	Epicenter	Magnitude & Depth	Region	Comments
Jan 5, 1326	8.0 S 158.9 E	7.1 47 km	Solomon Is.	No evidence of tsunami
Jan 6, 1539	10.5 S 164.5 E	6.8 32 km	Santa Cruz Is.	No evidence of tsunami
Jan 19, 0702	45.0 N 143.2 E	6.4 MB 204 km	Hokkaido, Japan	No evidence of tsunami
Jan 30, 1030	4.8 N 127.4 E	7.2 PAS 70 km	Talaud I., Philippine Is.	No evidence of tsunami
Feb 10, 2258	22.7 S 198.6 E	6.0 MB 673 km	South of Fiji Is.	No evidence of tsunami
Feb 11, 2216	6.7 S 126.8 E	6.0 MB 450 km	Banda Sea, Indonesia	No evidence of tsunami
Feb 17, 0043	3.8 N 128.4 E	6.5 14 km	North of Halmahera, Indonesia	No evidence of tsunami
Feb 20, 0956	3.5 N 128.2 E	6.4 33 km	South of Mindanao Philippine Is.	No evidence of tsunami
Feb 23, 0037	3.1 S 118.9 E	6.9 13 km	Celebes Is., Indonesia	Large waves along the western coast of Indonesia; 2000 people fled from coastal areas to escape the tsunami waves. Four villages were swept away. Extensive damage.